Installation of HLS at the ATF2

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1. Motivation
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1. Motivation

- Installation of an HLS system was suggested at an ATF2 project meeting last year.

GM-measurements

- Vibration measurement with seismometers at new ATF2 beam line and comparison with that in the ATF Ring.
- Floor movement measurement with HLS system.
- Measurement of daily variation of the floor tilt.

KEK Homeworks

5th ATF2 Project Meetings
19-21 December 2008, KEK

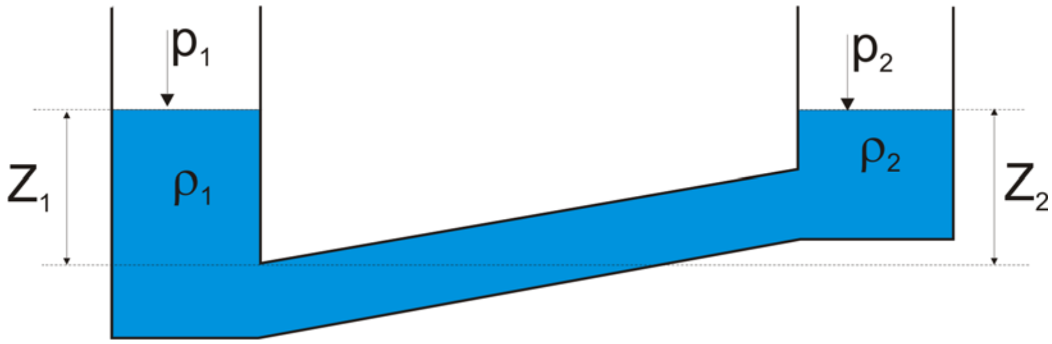
- HLS (water-tube tilt meter) has been adopted for wide variety of applications over decades.
- Very useful tool for monitoring ground motion, reference for accelerator alignment, etc.
- I raised the issue at CLIC pre-alignment workshop in April, where HLS & WPS were the main topics.

2.What is HLS?

HLS Principle

Hydrostatic Leveling Systems are based on the principle of communicating vessels or more precisely on the equilibrium of the pressure of the fluid in the communicating vessels. This is mathematically described by the Bernoulli equation.

$$p + \rho\, g\, Z = \text{const.}$$



$\Delta p = 0.10$ hPa => $\Delta Z = 1.02$ mm

$\Delta Temp = 1°C$; $Z = 100$ mm => $\Delta Z = 67\ \mu m$

2.What is HLS? advantages

Hydrostatic Leveling System Introduction

The proposed Hydrostatic Leveling System (HLS) determines height differences between points. Some of the advantages of the system are:

- No direct line of sight needs to exist
- Not affected by optical refraction
- High accuracy
- Fully automated
- In-situ calibrating
- Equipotential surface is the reference
- Absolute measurements before beam based alignment

advantages of HLS in accelerators

ILC

HLS

geoid/ellipsoid

advantages/disadvantages

DESY-HLS

electronics

mechanics

conclusion

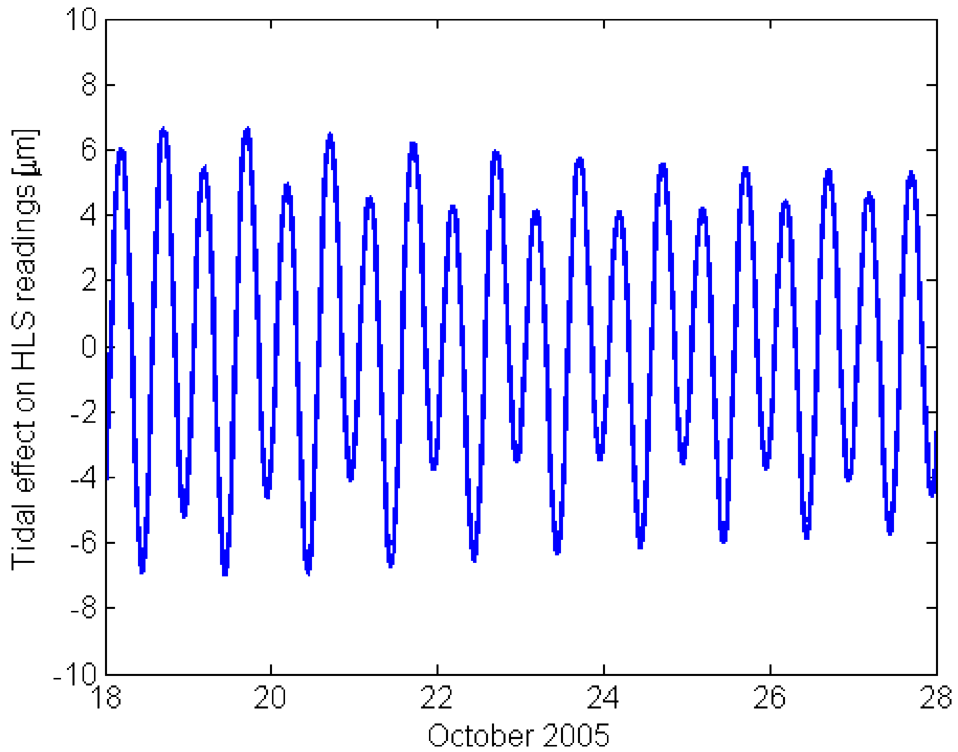
- HLS is a permanent measuring system which requires only little maintenance.
- High accuracy (1μm or even better) is possible
- Could be operated during accelerator runs
- Electronics can be easily separated from sensor, that makes shielding easy
- Could be used to monitor height movement of all (or only critical) components.
- automatic feedback system is possible
- accuracy is NOT influenced by geometric distance (if certain requirements are met - closed system, free surface, etc.)

2.What is HLS? disadvantages

Motion of Earth Surface

The disadvantage of using the equipotential surface as a reference is that the earth surface itself is not stable but in constant motion.

- Earth tides due to sun and moon
  - Up to 30µm for a 130 m long undulator
  - Can be modeled



- Ocean tide loading and atmospheric loading
  - Can reach up to 30 µm
  - Can't be easily modeled

disadvantages of HLS in accelerators

can't think of any ...

but wait ...

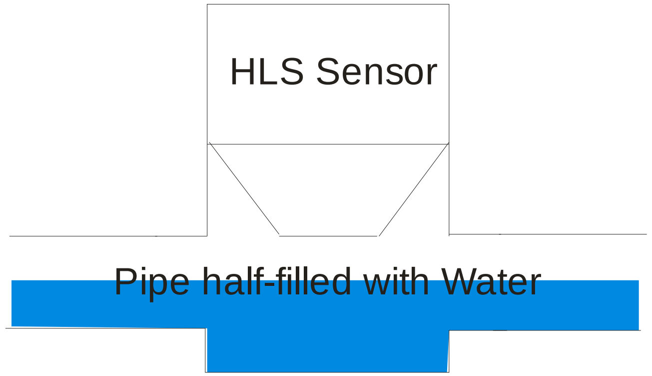
ok, if i try really hard ...

- allocates permanent space in tunnel
- costs money (not much, though)
- HLS detects only vertical movements - which is the main direction of movement for accelerator tunnels
- slow

WPS

HLS Configuration

- Half filled pipe system
  - Temperature differences do not affect the measurements
  - Pressure differences are prevented by closed pipes
  - Damping time ~10 min



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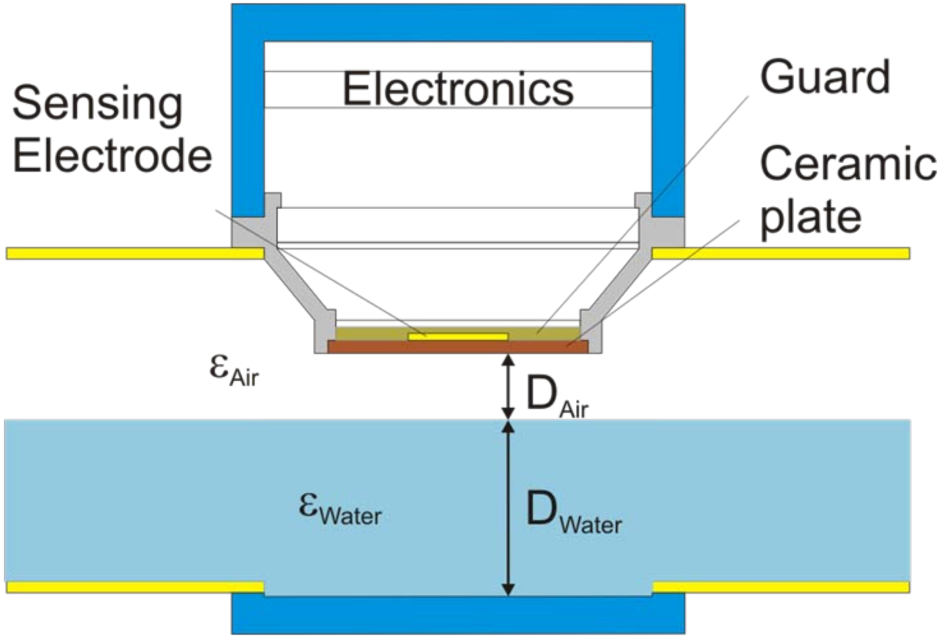
Types of Sensors - Capacitive Sensor (1)

- Principle
  Measures the Capacity C of the System

$$\frac{1}{C} = \frac{1}{C_{Air}} + \frac{1}{C_{Water}}$$

$$C = \frac{A \cdot \varepsilon}{D} + \text{fringe capacitance}$$



3. (capacitive) Sensors

~$1500 private communication with A.Chupyra (BINP)

Make	Installed at	Resolution	Cost /comments
Fogale nanotech	ESRF LHC J-PARC LINAC and many others	◎	Expensive($5500/sensor)
Budker	SLAC	◎	? They may give us several sensors
Balluff	FNAL Tevatron	○	$200/sensor (comm. With J. Volk)

項目	型式	品名	数量	単価	金額
		J-PARCリニアックアライメント用センサー			
1	V.HLS 12-14/4	HLSベッセル	10	40, 000	400, 000
2	PT100	T/Cプローブ	10	20, 000	200, 000
3	HLS.REM 5/0-50-J	HLSセンサー	10	594, 000	5, 940, 000
4	WPS-2D-B-10x10	WPS2Dセンサー	2	763, 000	1, 526, 000

3. Sensors

Examples of the other accelerators
FNAL
SLAC
J-PARC

Systems at Fermilab

1. 9 Budker sensors on the low beta quads at each interaction region
2. 204 Tevatron style sensors one on each Tevatron quadrupole
3. 5 Budker sensors in the LaFarge mine North Aurora Illinois
4. 7 Budker sensors in the near MINOS hall Fermilab
5. 11 Tevatron style sensors on floor in NMS hall photo injector test
6. 6 sensors various types stability test at MP-8 Fermilab
7. 12 Tevatron style sensors 200 ft level Homestake Gold mine Lead SD
8. 12 PoE and 3 Capacitive “hot” spares at MP-8
9. 9 Legacy Fogale sensors I have collected from old installations
10. 8 Fogale sensors on loan from Argonne Lab

There are many sensors at Fermilab.

Three types of Budker Institute sensors

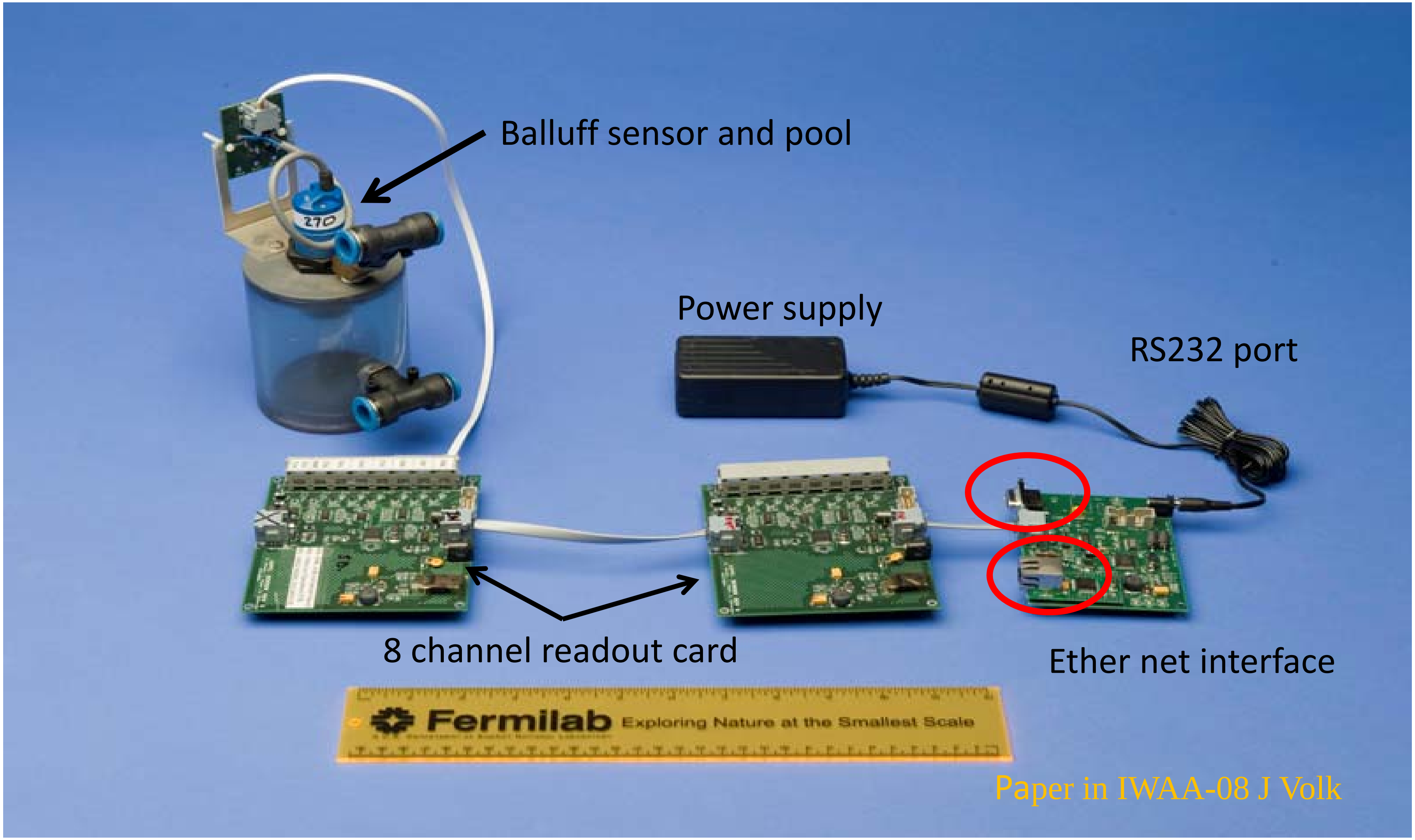
Capacitive sensors

Daisy chain power and readout

Power and signal over Ether net

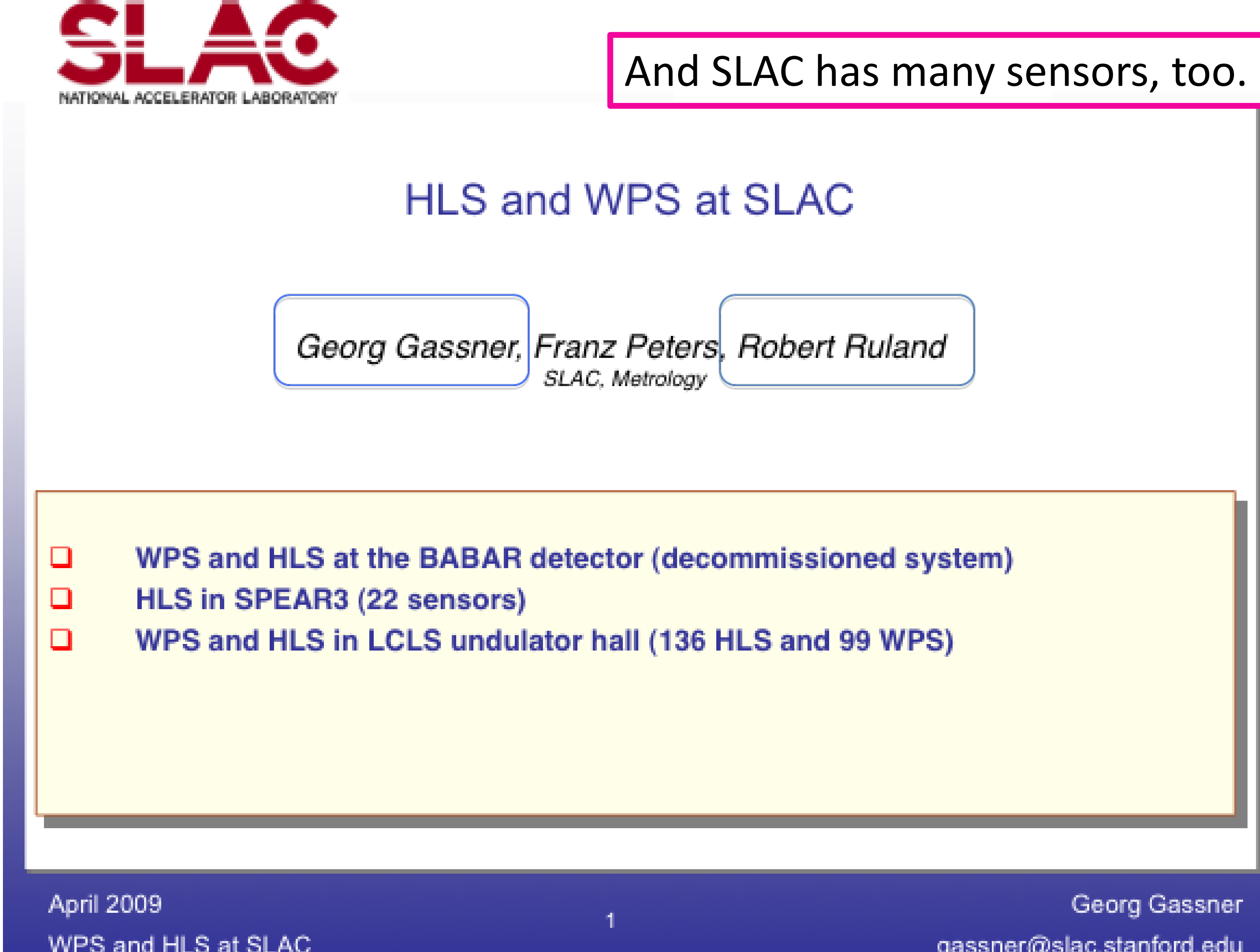
Ultra Sonic sensors power and signal over Ethernet

Fermilab design Tevatron style



Inexpensive

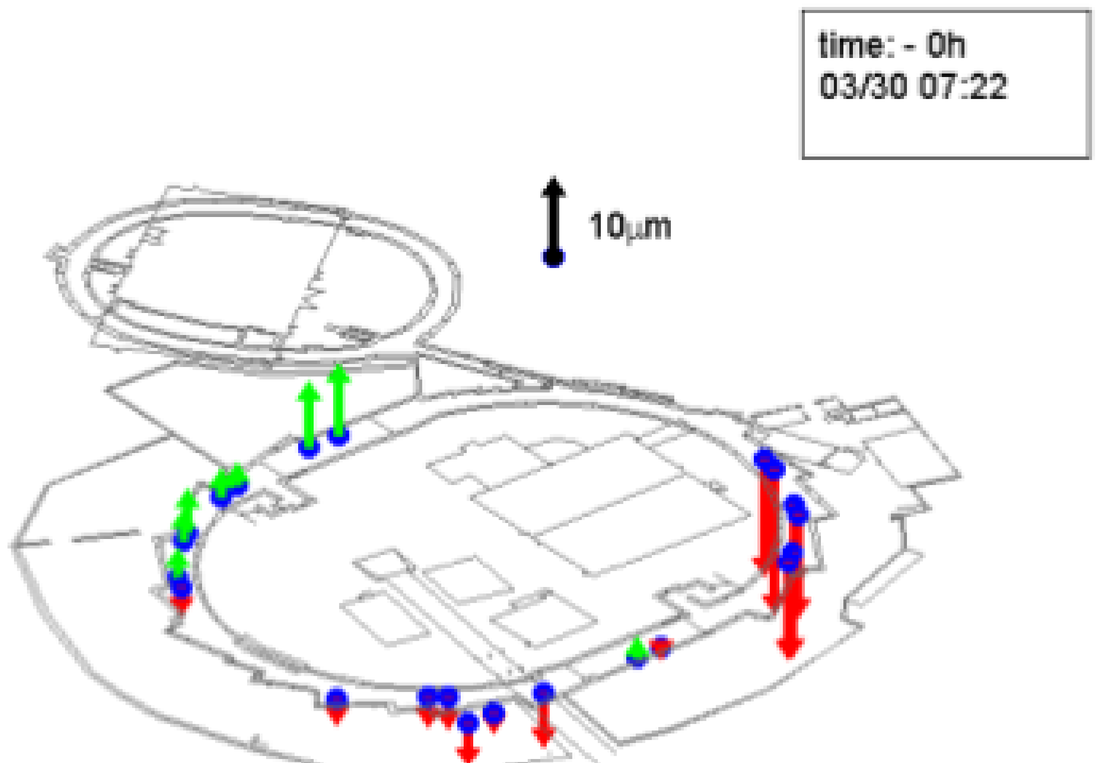
And SLAC has many sensors, too.



SLAC might give us some of their sensors (private communication with R. Ruland)

HLS in SPEAR3 (1)

- System contains 22 HLS sensors (in various configurations since 2005)
  - Third generation BINP sensors,
    - TCP/IP
    - Power over Ethernet
    - Sensor calibration at SLAC
  - 300 m circumference
  - 2 inch PVC pipe throughout



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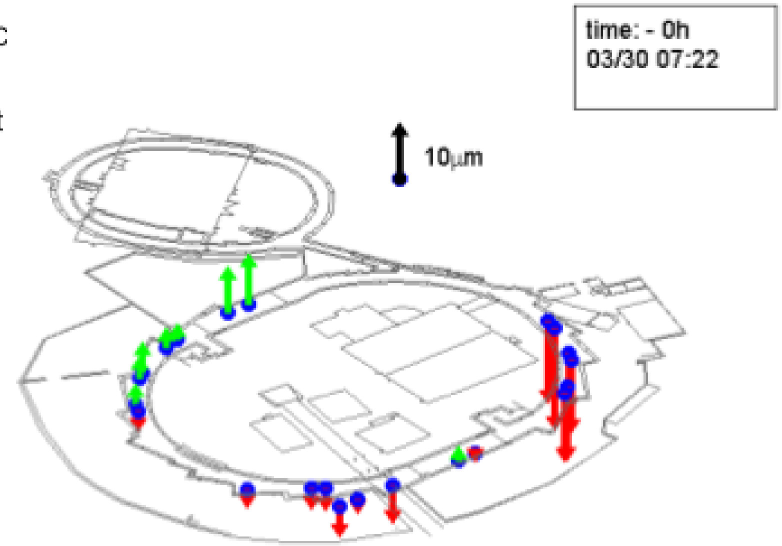
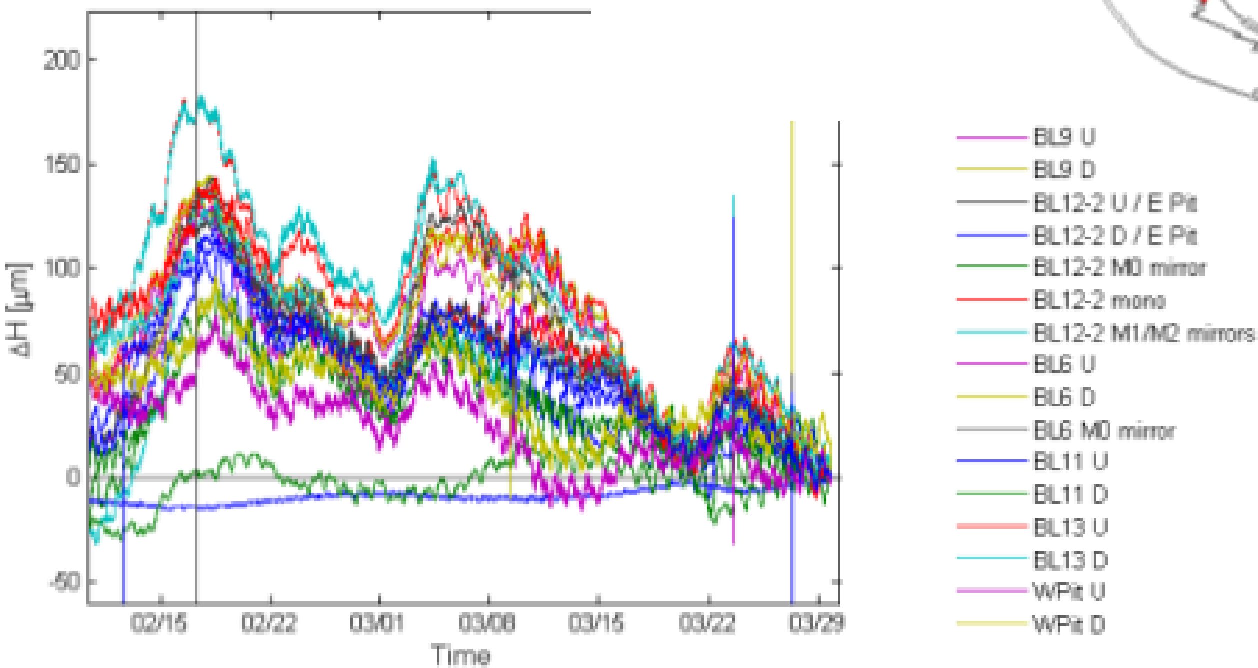
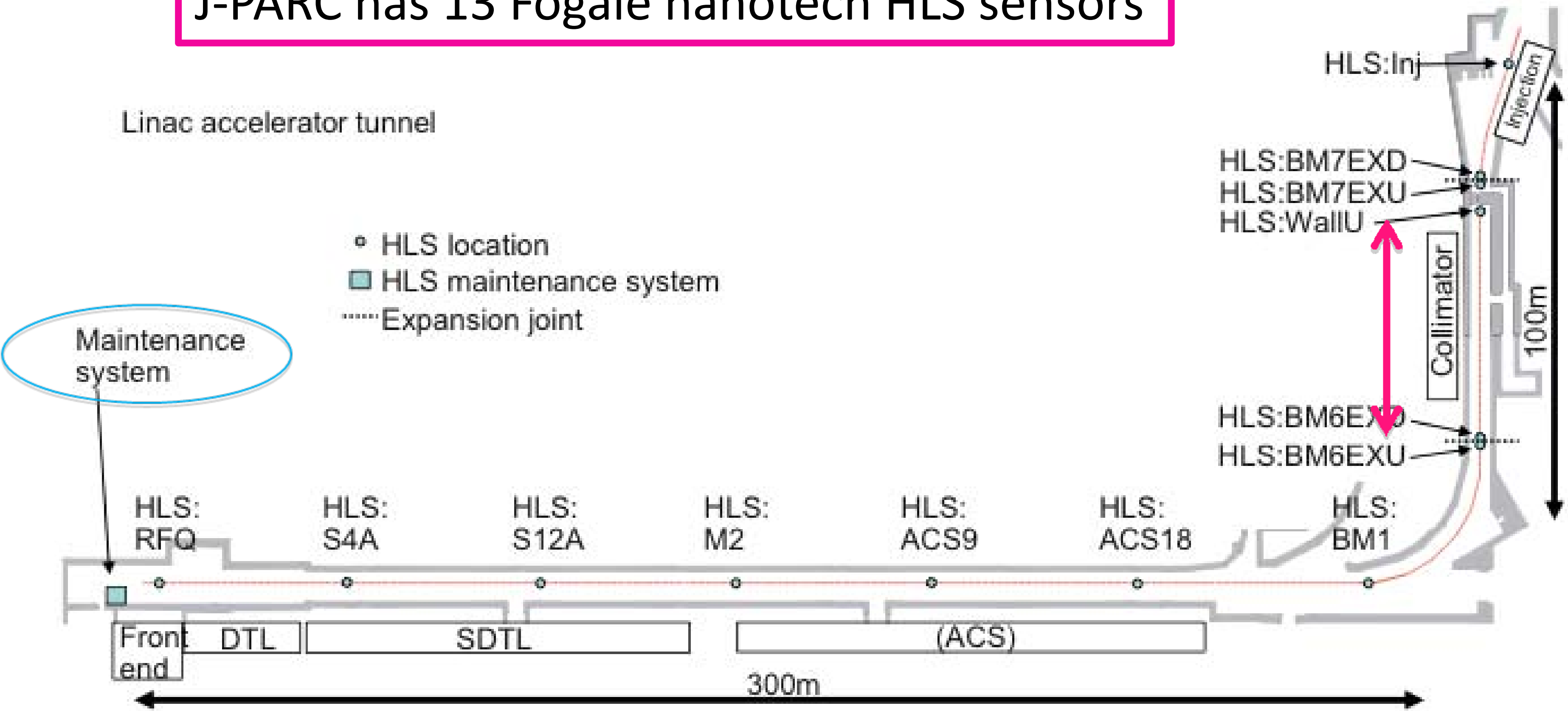
SLAC NATIONAL ACCELERATOR LABORATORY



- Latest results



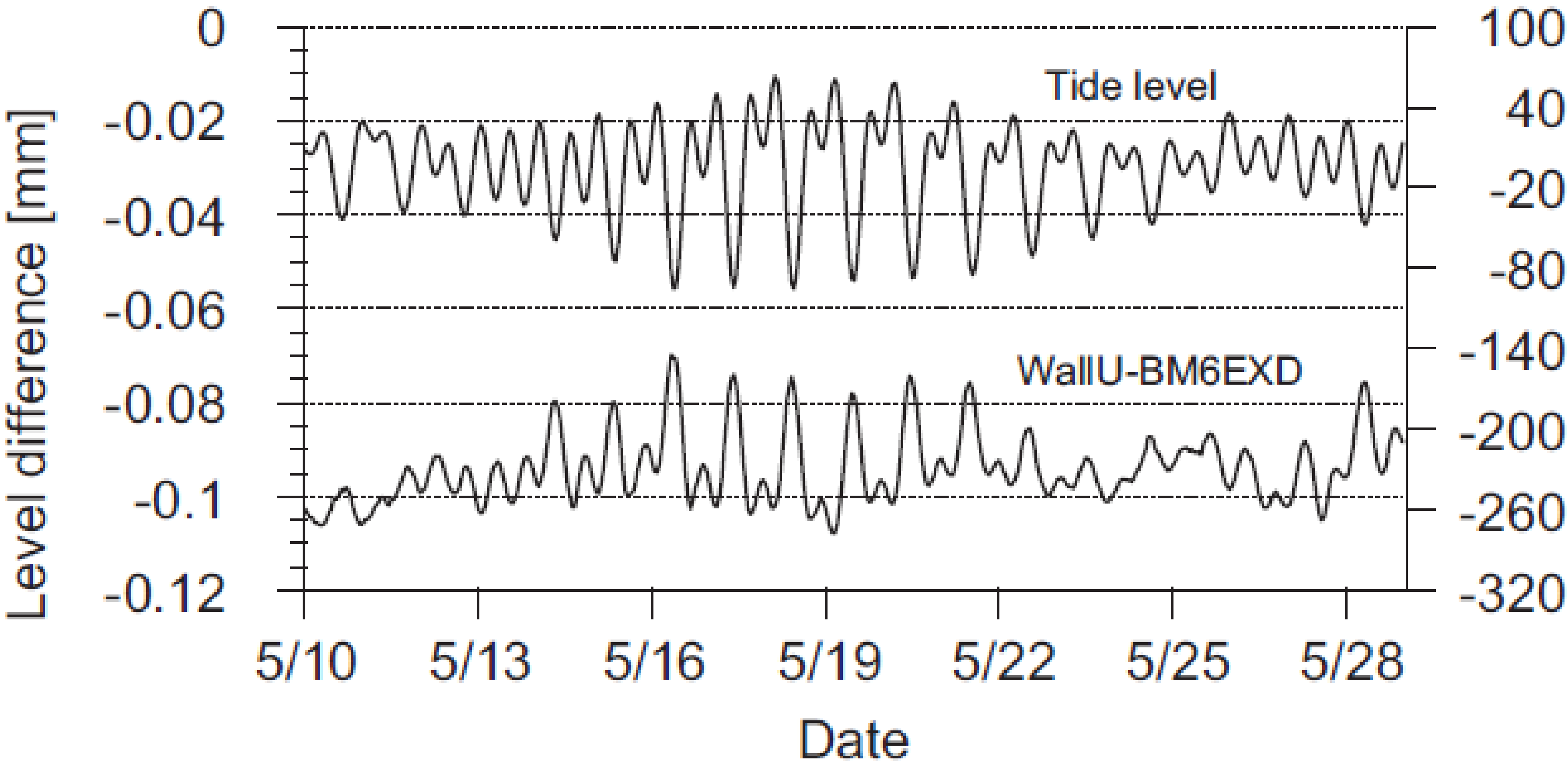
J-PARC has 13 Fogale nanotech HLS sensors



330 m straight section running from north to south
a west-to-east 65 m collimator section.
13 sensors in the linac accelerator tunnel with intervals of about 50 m.

Temperature variation ~1 degree/day, ~ 2 degree over months
Temperature spacial variation ~ 2 degree.

Slow ground motion observed at J-PARC linac



Relative water-level difference of two neighboring sensors and tidal level.
Data aquisition 1.5 seconds.
This monitoring system based on the hydrostatic leveling system is useful for monitoring the slow ground motion in J-PARC linac.

Possible approaches for homework

- ☆ Obtain available sensors from SLAC (Budker capacitive type)
- ☆ Purchase a few sensors of various types for R&D at ATF2
  - Fogale nanotech (capacitive)
  - Budker (capacitive or ultra sonic)
  - Tevatron type (capacitive)
  - Sugahara
  - Takeda
- ☆ Investigation of installation location (since it will be semi-permanent)
- ☆ Who will (be nice enough to) help me?
  - $$
  - man power
- ☆ Or do not do anything (forget about HLS for ATF2).

3. Sensors
Collaboration with SLAC

CLIC pre-alignment workshop (Apr.2-3, 2009)
ATF Software Task Team Meeting (Apr.8, 2009)

SLAC team (G. Gassner & R.Ruland) kindly agreed to collaborate with us on HLS.

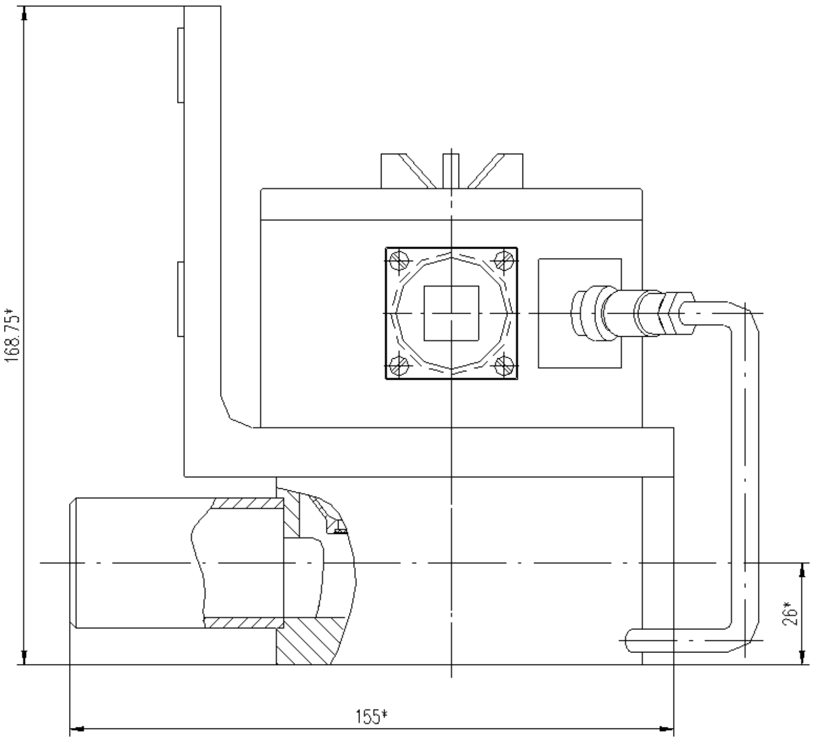
SLAC can provide:
Sensors, vessels,
data collection software
Support for the commissioning of the system

KEK needs to provide:
Pipes (2 inch), adapter, support for the water pipes,etc.
TCP/IP switch, Ethernet cables…, PC
Installation man power

SLAC sensor & vessel

SLAC mounting bracket

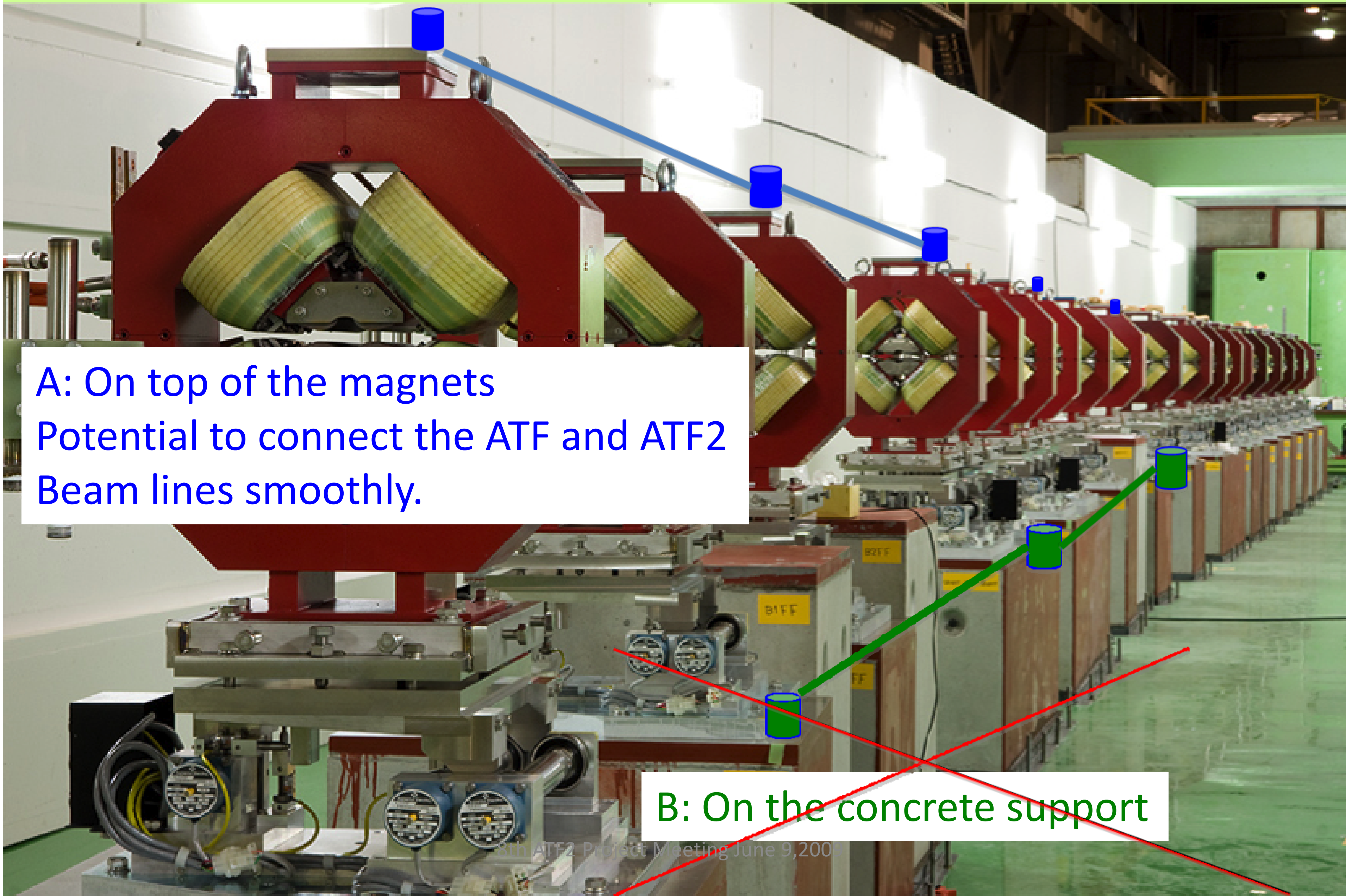
SLAC sensor & vessel



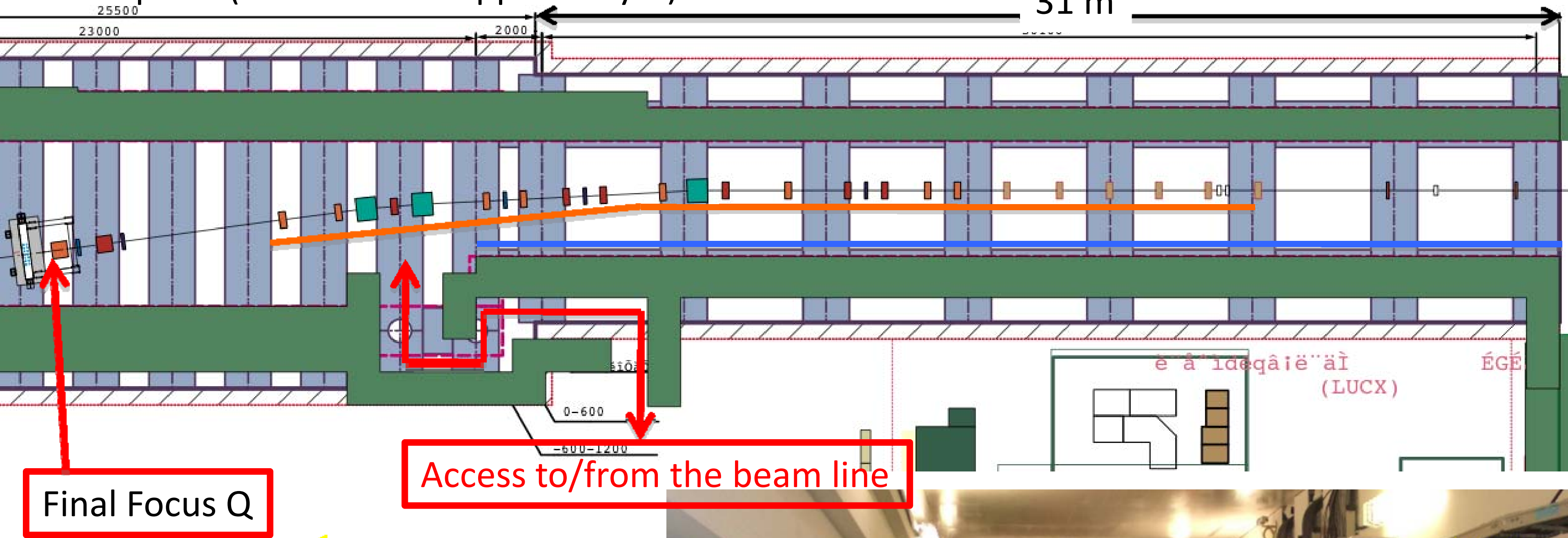
4. Installation locations at ATF2

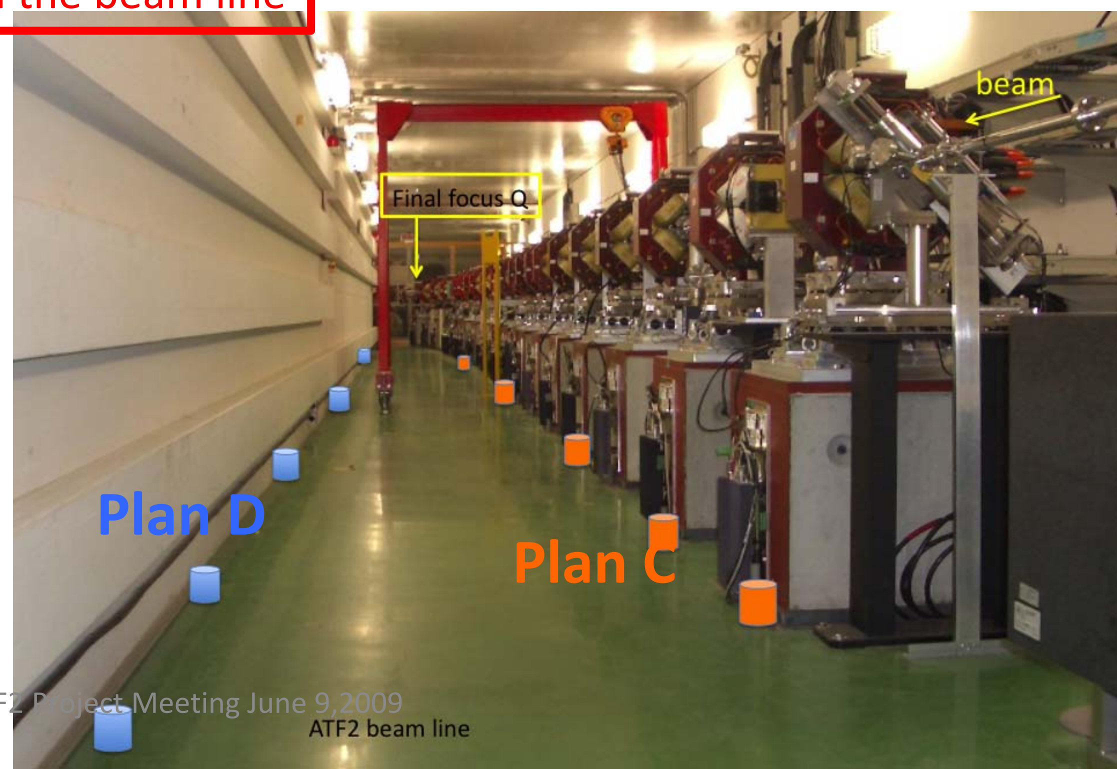
4 plans (A,B,C,D)
A is my favorite, of course

Possible Installation locations: Plan A & B



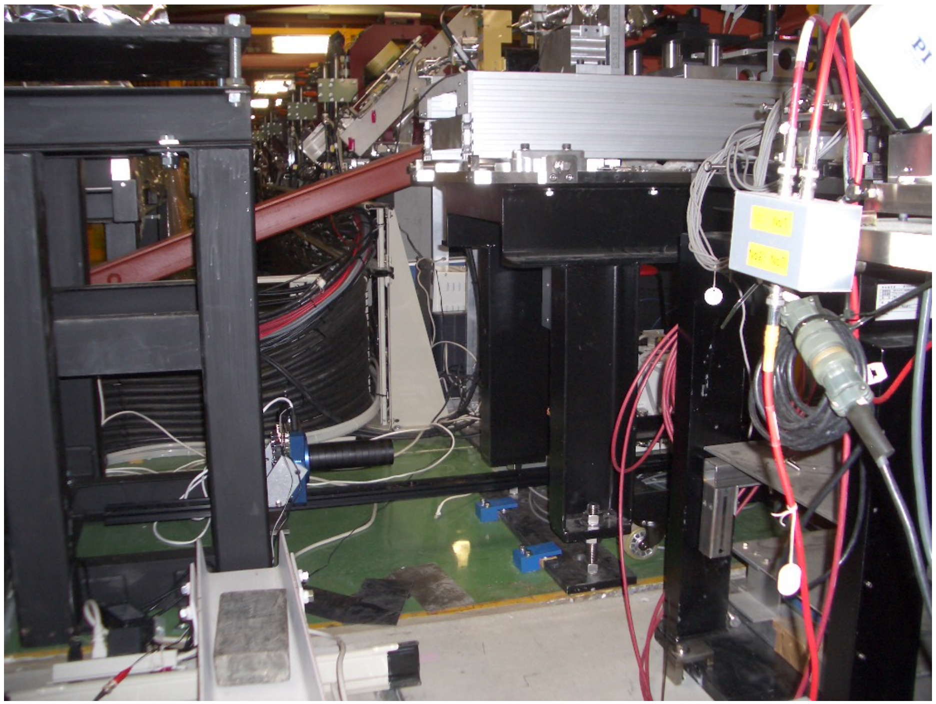
Proposal (has not been approved yet)

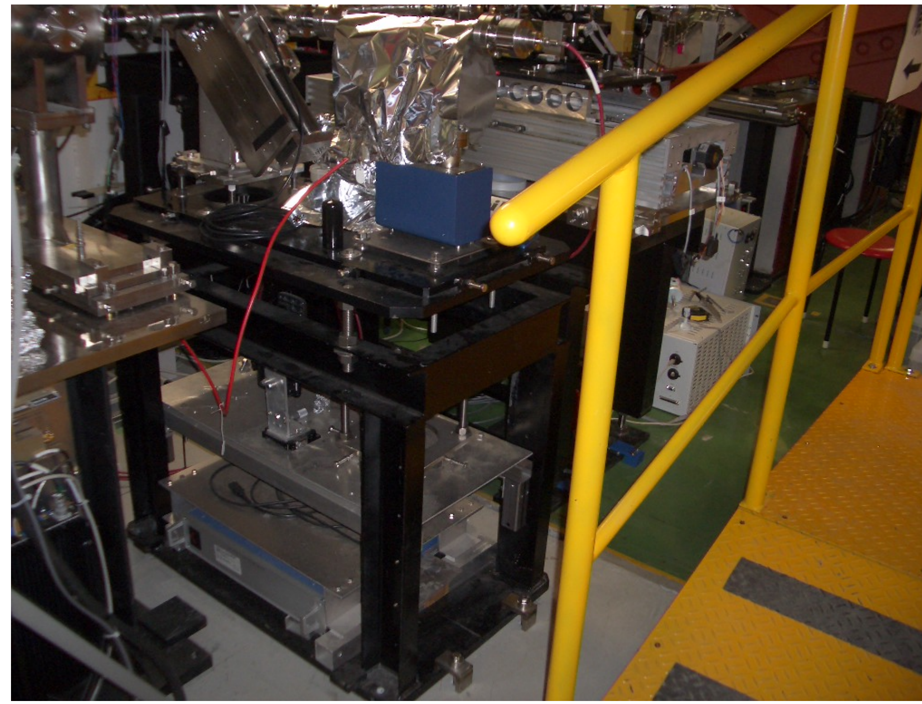




Plan C&D short span

Border between ATF floor and ATF2 floor is crowded





Summary

- HLS has been used to monitor the slow ground motion at many beamlines (light sources, colliders such as LHC, CLIC & Tevatron).

- It will most likely be required for the ILC as well.

- We would like to install an HLS system at the ATF2 beamline, which will permit us to study the effects of ground motion on (low emmittance) beam quality.

- We would like to install a WPS system as well in the future.